Key Determinants of Information and Communications Technology to Promote Knowledge-based Economy in East Asia

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Abstract

In the last couple of decades, many countries have shown high economic performance by knowledge creation and diffusion to the various sectors of the economy, which has come to be described as knowledge-based economy. It is now well established that knowledge created through innovation and technological progress is the long-term driver of economic growth. One of the fundamental challenges in an emerging knowledge-based economy is to harness knowledge for development by providing an enabling environment of excellent information and communications technology (ICT) infrastructure. As such, it is needless to say that the whole process of knowledge creation and diffusion in a knowledge-based economy heavily depends on ICT infrastructure. Many East Asian governments have shown remarkable success in creating a knowledge-based economy by developing appropriate ICT infrastructure. This paper attempts to identify the key determinants of ICT to promote a knowledge-based economy in East Asia.

Keywords: Information and Communications Technology (ICT), Knowledge-based Economy, Japan, Korea, Taiwan, Hong Kong and Singapore

Ⅰ Overview

The presence of a functioning information communications technology (ICT) has been of great importance for enhancing economic activities with much faster speed than ever before. The widespread use of ICT in economic and social sectors has drastically shaped the so-called knowledge-based economy. In last couple of decades, ICT especially has transformed the knowledge-based economic growth of many countries of the world.

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This is more so in the case of knowledge-based economies where the generation, diffusion, absorption and application of new technology and knowledge flow with a much faster speed to enhance competitive economic development. ICT, by many scholars, has been pointed as a major factor in this faster flow of technology and knowledge in the knowledge-based economies. ICT, by providing the necessary connectivity among places and people in East Asia is playing very important role at all levels such as national, regional and global. The movement of new inventions or innovations or their impacts reach the countries within very short-time which, in turn forces all the knowledge-based economies towards continuous innovations to remain competitive in the global market. Experiences over the past decades in East Asia have shown that a competitive ICT sector is extremely important for knowledge-based economies. As a result, the knowledge-based economies in East Asia have been launching new policies towards creating a better ICT infrastructure to maximize their economic endeavors in a globally competitive world. This paper examines the determinants of ICT to promote knowledge-based economy in East Asia. Here ICT has been considered as a general-purpose technology similar to power delivery systems and other technological infrastructures.

After the Second World War, the government of Japan had shown great success in attracting large amount of foreign assistance and expertise to enhance economic growth. During the high growth era of 1970s and 1980s, Japanese government policies enabled the transformation of Japanese economy into a knowledge-based economy. The efforts by the government were fully paid off as Japan gradually became world's second largest economy after the U.S. The phenomenal growth of Japanese economy largely depended on the successful development of ICT. Following the similar foot step, the governments of other East Asian Economies have shown remarkable success in creating a knowledge-based economy by developing the necessary ICT infrastructure. Korea, Taiwan, Hong Kong and Singapore had been tremendously successful in the regard. Malaysia and China have also shown great success in this regard as late comers in the region. Consequently, this study focuses on Japan, Korea, Taiwan, Hong Kong, and Singapore to investigate the key determinants of ICT to promote knowledge-based economy in East Asia.

Ⅱ Building the ICT Infrastructure in East Asia

During the high growth period of Japan in the 1960s and 1970s, the telecommunication sector greatly contributed to the economic development by increasing productivity and marketing. Japan realized the importance of communications technology in the early stages of their economic take off after World War II, while many other East Asian economies such as Korea, Taiwan, Hong Kong and Singapore began only later. In

most of the East Asian economies, the development of telecommunications sector got the necessary attention when the Japanese foreign direct investment was flowing in huge volume. The industrial hollowing out in Japan made this even faster. By the 1980s, many scholars (OECD, 1996) started recognizing information as a crucial factor of production along with capital and labor. Finally in the 1990s, with the rapid technological advancement ICT became one of the most critical factors for competitiveness and growth in the East Asian knowledge-based economies. During the 1990s, the availability of computers further added value to the ICT infrastructure in East Asia. Later, the wide spread use of internet and mobile phone revolutionized the ICT sector in East Asia. Today, ICT has become one of the most important sectors in furthering knowledge-based economic growth in most of the East Asian countries.

It will not be exaggerating to say that the East Asian economies received the necessary technology and knowledge transfer for ICT infrastructure development from the advanced countries and later improved on the transferred technologies and knowledge. In East Asia, Japan was considered as a country of imitation as it highly depended on US or other European technologies and know-how to make necessary technological progress. In terms of building the ICT infrastructure, the long experience of adopting and adapting foreign technology helped Japan to design its own ICT infrastructure that best fitted the Japanese market. Later, other East Asian countries followed similar path by adopting technology and know-how from Japan to build up their ICT infrastructure. East Asian countries, in this regard, employed three main channels to acquire advanced foreign technologies and knowledge such as international trade, foreign direct investment and disembodied knowledge flows in ICT sector (Archibugi and Pietrobelli, 2003). The East Asian countries, especially, the advanced knowledge-based economies in the region such as Japan, Korea, Taiwan, Hong Kong and Singapore have been investing in the development of ICT infrastructure in their pursuit towards knowledge-based economic growth by using all the three channels.

Ⅲ Relationship between Foreign Direct Investment (FDI) and ICT in East Asia

Until the 1980s, ICT services such as telecommunications had been monopoly business owned either by the state or by heavily regulated private entities throughout the world (Guislain, P. *et al*., 2006). Japan and other East Asian economies were no exception to this. As ICT industry is capital-incentive, the initial growth of ICT sector in East Asia had been very slow. Although foreign direct investment had been a great source of capital for other sectors of many East Asian countries, the ICT sector received the lowest FDI.

Since the mid-1980s, many countries realized the importance for privatization of the ICT sector to receive FDI for faster growth of the sector. Japan was first among the developed East Asian economies to open this sector for private investment and competition in 1985 (Guislain, P. *et al*., 2006) . Many other East Asian economies followed a similar pattern that allowed FDI to flow in the telecommunications services of the ICT sector. With the introduction of mobile phone technology, huge amount of FDI flew to the East Asian countries. The cost-effectiveness of mobile networks and positive government policies towards new technologies soon surpassed the wired telephone industry in many East Asian countries.

There is also a growing acknowledgment that ICT acts as a strong catalyst to attract FDI which has been the single most important factor in East Asia's knowledge-based economic growth. The available literature on the relationship between ICT and FDI (Economou, P., 2008) looks at ICT as a 'location' factor for attracting FDI that also influences other determinants of FDI. A recent study on the relationship between ICT and FDI found that ICT and the diffusion of new ICT instruments are significant 'pull' factors for attracting FDI (Gani and Sharma, 2003). Gholami, Lee, and Heshmati (2006) also mentioned in their study on 'The Causal Relationship Between Information and Communication Technology and Foreign Direct Investment' that there is a causal relationship between ICT investment and increase of FDI flow. There is strong evidence that ICT development causes FDI inflow whereas there is only partial evidence that inflow of FDI helps the development of ICT.

ICT, in many ways, influences other determinants of FDI inflow in East Asian knowledge-based economies to a great extent. East Asia's FDI-based and domestic both innovations have been extensively supported by the ICT. Many studies show a positive relationship between the availability of ICT infrastructure and innovation. Persephone Economou (2008:6) points out that ICT exerts a positive influence on innovation and entrepreneurship, which are particularly important determinants of FDI, especially technologically intensive investments and enhances the attractiveness of countries to export-oriented FDI as ICT provides the logistical support to facilitate exporting and that contributes to a country's attractiveness to foreign investors seeking to establish a presence in order to serve regional or global markets. Another study by Vinod (2005) states that ICT helps improve transparency in the host countries and reduces corruption, which works as a hindrance to FDI.

The superior ICT infrastructure in the East Asian knowledge-based economies, especially in Korea, Taiwan, Hong Kong and Singapore is creating enough scope for the absorption of spillovers arising from FDI by enhancing knowledge and skills among them from the R&D activities and other business activities of multinational corporations. The

above countries including the East Asian giant Japan have the privilege to connect the economic activities of different regions or businesses or communities through the linkages available due to strong ICT infrastructure present in those countries.

Ⅳ ICT's Investment Facilitating Role in East Asia

As ICT becomes more widely available in the East Asian knowledge-based economies, its use evolves to better suit the changing needs of increasingly sophisticated investment as the investors benefit from ICT-based investment promotion because many a time, they rely on the easy and cheap access to evaluate projects in different locations. Increased access to ICT by the enterprises in East Asia is helping them to have better and efficient access to information on the one hand and to use the ICT infrastructure to increase the productivity on the other hand. The presence of strong ICT infrastructure in the host countries helps the companies to expand their businesses. ICT applications are facilitating the investments in East Asia by significantly increasing productivity. It is creating potential investment space by making reconfiguration of work organization both within firms and among firms as well as with the rest of the economy (Information Economy Report 2007-2008).

Ⅴ Expanding ICT Services in East Asia

The investment in telecommunications has been declining since 2002 (See Table 1) in all the major knowledge-based economies in East Asia. One of the major reasons behind this is the decreasing rate of investment in the saturated fixed telephone market (See Figure 1) and there is very little scope of further growth in this sector. Another reason is that the mobile telephone has taken the place of fixed telephone in many cases because of convenience of use and availability of different applications.

Since the mid 1990s, mobile telephone has become one of the very crucial ICT tool emerging in the East Asian economies. The continued and substantial growth in mobile phone subscribers can be confirmed from 2002 to 2007 (See Figure 2). The major East Asian knowledge-based economies (Japan, Korea, Taiwan, Hong Kong and Singapore) have shown very high level of mobile phone penetration for the period 2002-2007. This increase in the use of mobile phones drastically reduced the so-called 'digital divide' among the people who had limited access to fixed phone lines in Thailand and Malaysia. Mobile phones are being used increasingly not only for personal purposes, but also for business purposes through mCommerce, mEnterprise (enterprise solutions enabled through mobile phones such as logistics) and mServices (applications in mobile phones

Table 1. Investment in Telecommunications, East Asia

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
China	N/A	N/A	N/A	N/A	1.72	1.63	1.37	1.15	1.04	0.95
Hong Kong	N/A	N/A	N/A	N/A	0.65	0.65	0.60	0.68	0.41	N/A
Indonesia	N/A	N/A	N/A	N/A	N/A	N/A	0.66	0.55	0.43	N/A
Japan	N/A	N/A	N/A	N/A	0.49	0.47	0.44	0.42	0.40	0.42
Korea	N/A	N/A	1.49	1.09	0.97	0.81	0.75	0.67	0.74	N/A
Malaysia	2.09	1.86	1.56	1.42	1.33	0.82	0.67	0.88	0.83	N/A
Philippines	N/A	N/A	N/A	N/A	0.91	N/A	1.02	N/A	N/A	N/A
Singapore	N/A	N/A	N/A	N/A	0.49	N/A	0.39	0.38	0.33	N/A
Taiwan	N/A	N/A	N/A	N/A	0.88	1.16	0.75	0.47	0.45	N/A
Thailand	N/A	N/A	N/A	N/A	1.19	0.28	0.32	0.37	0.37	0.39

Source: International Telecommunication Union, www.itu.int, World Telecommunication/ ICT Indicators Development, and National sources.

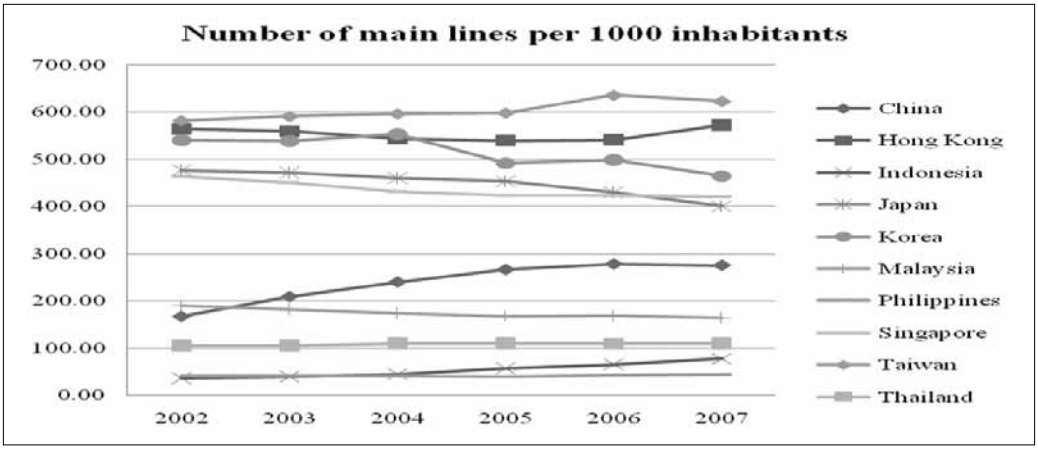

Figure 1. Fixed Telephone Lines, East Asia

Source: International Telecommunication Union (www.itu.int), World Telecommunication/ICT Indicators Development, and National sources.

such as mobile banking) (O'Donnel *et al.*, 2007).

The availability of computers, in many ways, indicates the level of ICT infrastructural development of a country to become a knowledge-based economy. Many studies found strong relationship between the availability of computers and the level of knowledge base of a country. The East Asian knowledge-based economies are not exception to the above observation. The availability of computers (See Figure 3) has increased in the past few

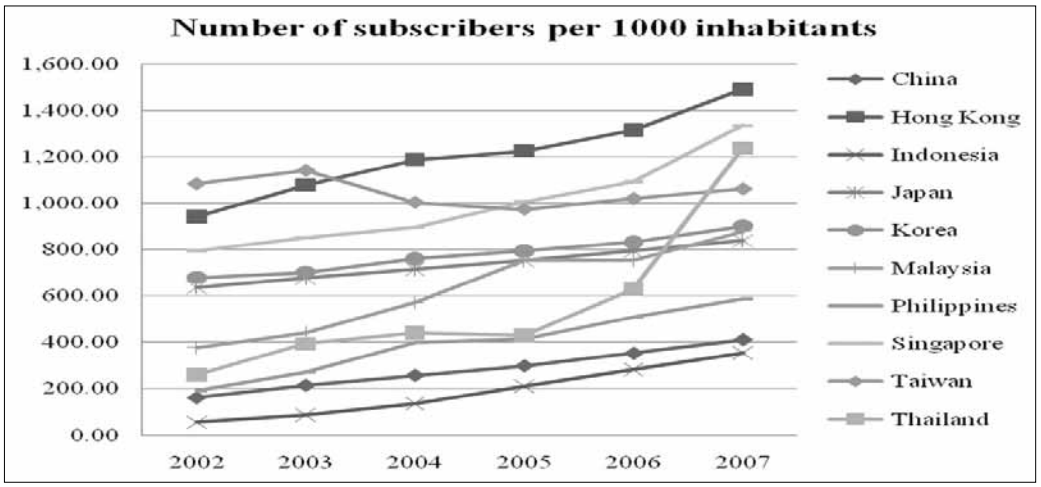

Figure 2. Mobile Telephone Subscribers, East Asia

Source: International Telecommunication Union, www.itu.int, World Telecommunication/ICT Indicators Development, and National sources.

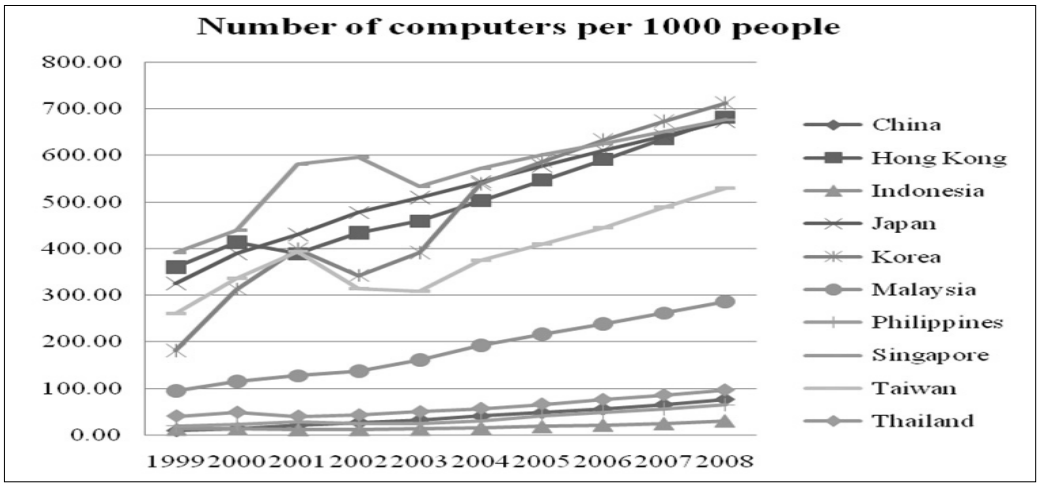

Figure 3. Computers per Capita, East Asia

Source: Computer Industry Almanac Inc. April 2009 (http://www.c-i-a.com) and National sources.

years throughout East Asia. The five advanced knowledge-based economies of East Asia such as Japan, Korea, Taiwan, Hong Kong and Singapore have achieved phenomenal success in this regard. The number of computers per 1000 people reached almost 700 in year 2008.

The growing use of internet has been helping the growth of production capacity in the East Asian countries, which, in turn, increased the domestic investment as well as FDI

inflow. A study by Changkyu Choi (2003) found a direct correlation between the growth of Internet use and FDI inflow whereby a 10 percent increase in internet use is correlated with a 2 percent increase in FDI inflow. In East Asia, Internet is helping to lower prices by reducing search costs for business to business, business to consumers and contributing to the efficient functioning of both domestic and export markets (Persephone Economou, 2008:6).

Ko (2007) also supported the strong relationship between the Internet and FDI, finding that positive network externalities associated with Internet usage encourage FDI inflow. The increase in internet use has a positive impact in the growth of exports as internet shortens the transaction costs and other business related costs. A recent study has found that in recent years a 10 percentage point increase in the growth of Web hosting in a country leads to about a 0.2 percentage point increase in export growth (Freund and Weinhold, 2004). In observing the use of internet in East Asia, we see that Internet use in most of the countries in the region (See Figure 4) has drastically increased in the past few years. Japan, Korea, Singapore, Hong Kong and Taiwan are the top countries in the region in terms of Internet users per 1000.

It is now well known that broadband access has significant impact on the productivity of enterprises by allowing the enterprises to adopt the necessary application. Many industries are now adopting e-business solutions by using broadband internet in East Asia to explore new business opportunities as well as to enhance cost-saving potentials. Consequently, in terms of the number of broadband subscribers per 1000

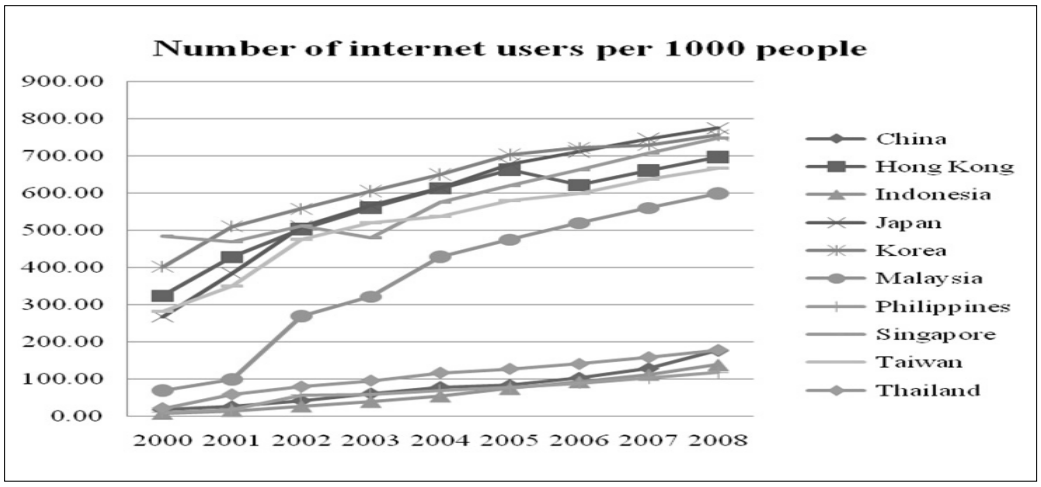

Figure 4. Internet Users, East Asia

Source: Computer Industry Almanac Inc. April 2009 (http://www.c-i-a.com) and National sources.

people since 2002, there is a huge annual increase every year in almost all the East Asian countries. However, here, too, Japan, Korea, Singapore, Hong Kong and Taiwan are the leading countries in the region (See Table 2).

With increasing developments in information technology the companies are increasingly facing problems with cyber security. Without the availability of appropriate cyber security system, the IT can be devastating by creating huge technological downfall

Table 2. Broadband Subscribers, East Asia
(Number of subscribers per 1000 inhabitants)

Country	2002	2003	2004	2005	2006	2007
China	4.18	8.14	19.84	28.68	38.73	50.26
Hong Kong	146.66	182.83	224.04	243.51	261.95	274.17
Indonesia	0.18	N/A	N/A	N/A	0.88	1.14
Japan	73.74	116.89	116.83	N/A	206.84	221.39
Korea	218.50	233.56	248.16	253.25	290.76	303.57
Malaysia	0.79	4.40	9.88	19.20	33.75	37.21
Philippines	0.26	0.68	N/A	N/A	1.39	5.48
Singapore	64.66	102.48	122.98	156.03	180.97	195.07
Taiwan	93.25	134.63	165.33	190.64	196.96	208.65
Thailand	0.24	0.70	0.69	N/A	1.61	13.89

Source: International Telecommunication Union (www.itu.int), World Telecommunication/ICT Indicators Development and National sources.

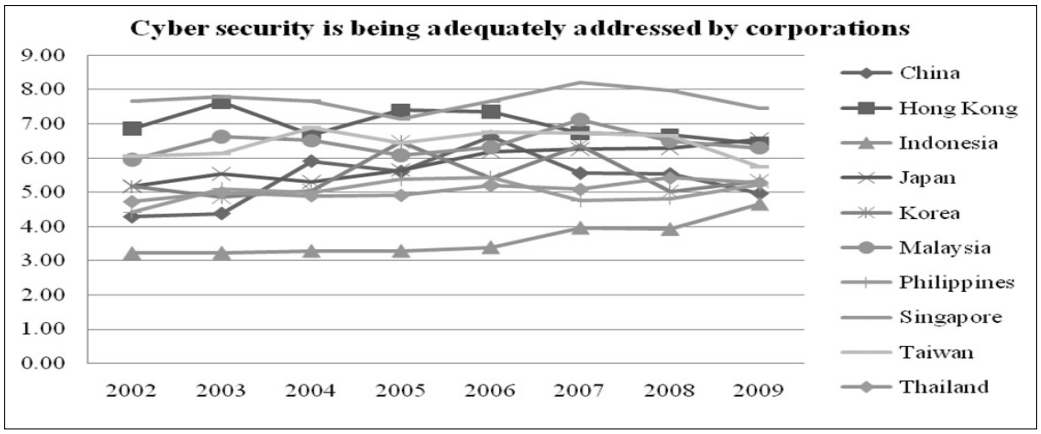

Figure 5. Cyber Security, East Asia*

* IMD WCY Executive Opinion Survey based on an index from 0 to 10.

Source: Computed from data collected from IMD World Competitiveness Online 1995-2009. Updated: May 2009.

in both private and public sectors. It is usually expected that the corporations would develop their own cyber security system in order to protect themselves from technological disasters. Enterprises in most of the East Asian knowledge-based economies have developed competent cyber security system (See Figure 5) against technological uncertainties.

Ⅳ Role of ICT in Enhancing Competitive Business Environment

The availability of a competitive ICT infrastructure is one of the key factors in the development of knowledge-based economy. The use of the computer, internet and other ICT tools to enhance business and production efficiency has been quite extensive in the region. ICT while helping other industries flourish rapidly it itself became one of the major industries for the East Asian knowledge-based economies. In today's competitive globalizing world, ICT is providing competitive business environments in East Asia which helps the East Asian enterprises to be globally competitive. The communications technology that meets business requirements (data and voice) has been extremely satisfactory in Japan, Korea, Taiwan, Hong Kong and Singapore for the last six years (See Figure 6).

Along with the increase in the number of available computers, computer users,

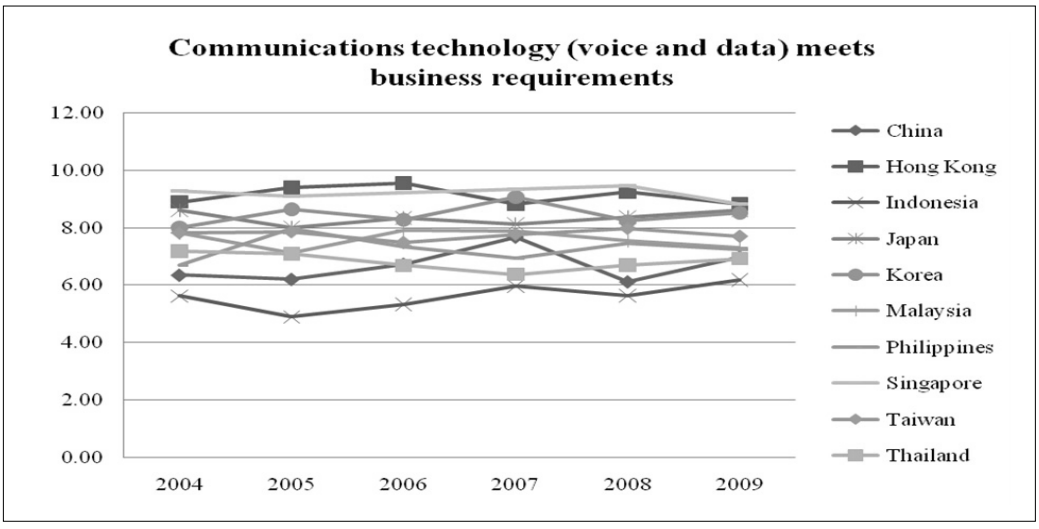

Figure 6. Communications Technology*, East Asia

* IMD WCY Executive Opinion Survey based on an index from 0 to 10.

Source: Computed from data collected from IMD World Competitiveness Online 1995-2009. Updated: May 2009.

internet users and broadband subscribers, the information technology skills also developed significantly in the major knowledge-based economies in East Asia (See Figure 7). The availability of computers and internet created necessary environment to develop the information technology skills which is extremely important in a knowledge-based economy. The educational institutions and other professional training institutions are playing an important role in this regard by training the young people with the necessary information technology skills.

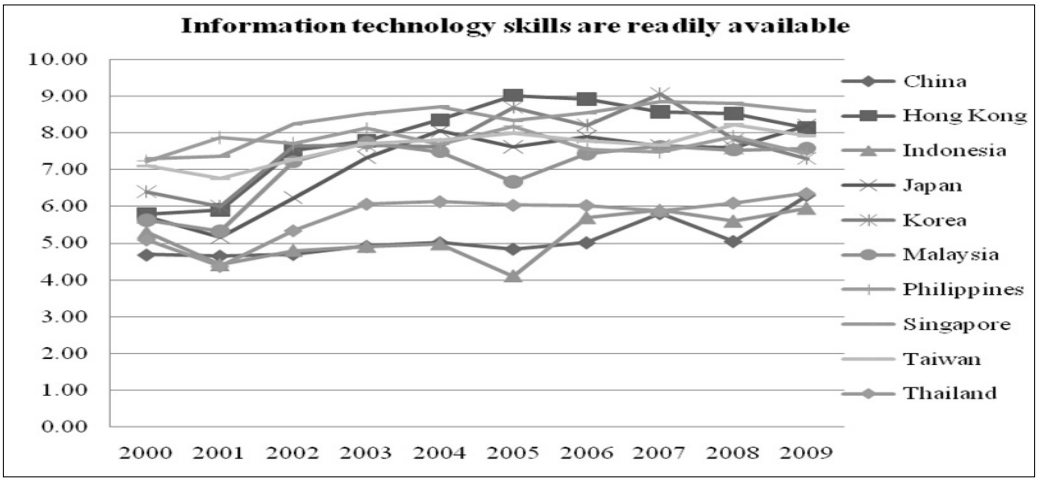

Figure 7. Information Technology Skills, East Asia*

* IMD WCY Executive Opinion Survey based on an index from 0 to 10.

Source: Computed from data collected from IMD World Competitiveness Online 1995-2009. Updated: May 2009.

The technological cooperation among companies in East Asia also increased in the last few years (See Figure 8), indicating that the companies are preparing themselves to meet the high competitions in a knowledge-based economy. Not only are the private companies cooperating with each other in technology development but also the public and private sector ventures are supporting the technological development. In the recent years, there has been an increasing trend in the private-public partnerships for technological developments (See Figure 9).

The development and application of technology largely depend on the legal environment of a country. The advanced knowledge-based economies realized this at the early stage of their journey towards knowledge-based economy. The legal environment (such as legal protection for patent rights) for technological development and application has become better during the last 10 years (See Figure 10). Parallel to the legal environment for the development and application of technology, the technological

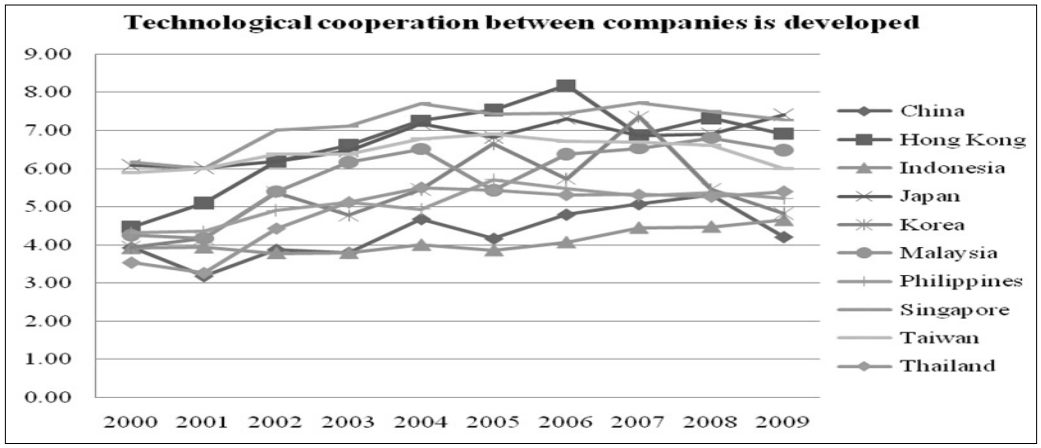

Figure 8. Technological Cooperation, East Asia*

* IMD WCY Executive Opinion Survey based on an index from 0 to 10.

Source: Computed from data collected from IMD World Competitiveness Online 1995-2009. Updated: May 2009.

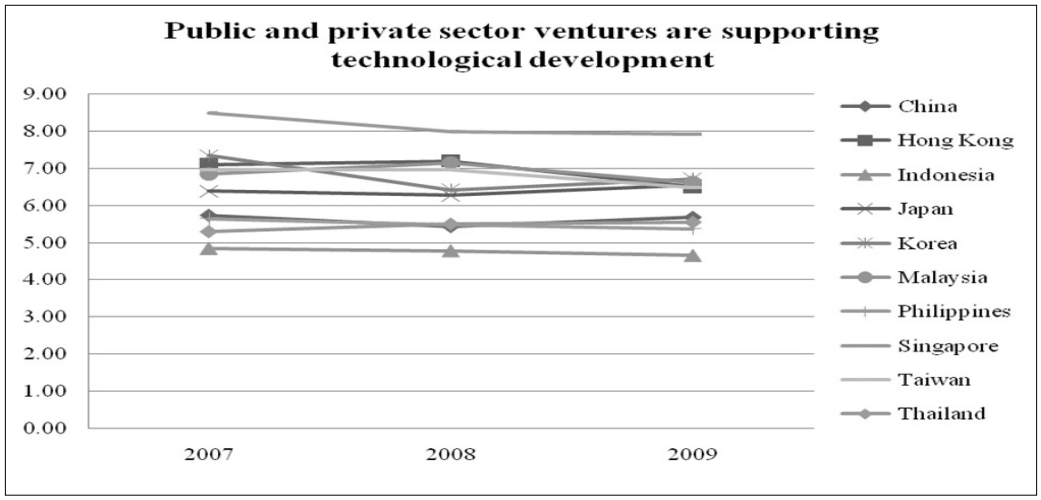

Figure 9. Public and Private Sector Ventures, East Asia**

** IMD WCY Executive Opinion Survey based on an index from 0 to 10.

Source: Computed from data collected from IMD World Competitiveness Online 1995-2009. Updated: May 2009.

regulations to support business development and innovation also have been fine tuned particularly in Japan, Korea, Taiwan, Hong Kong and Singapore. In line with legal environment for development and application of technology, there have been strong and functioning technological regulations in most of the East Asian countries that are

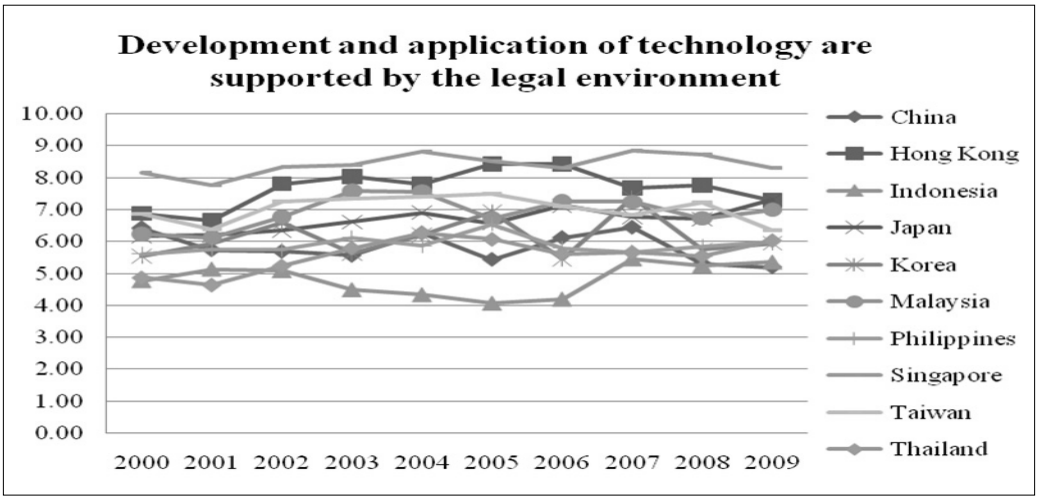

Figure 10. Development and Application of Technology, East Asia*

* IMD WCY Executive Opinion Survey based on an index from 0 to 10.

Source: Computed from data collected from IMD World Competitiveness Online 1995-2009. Updated: May 2009.

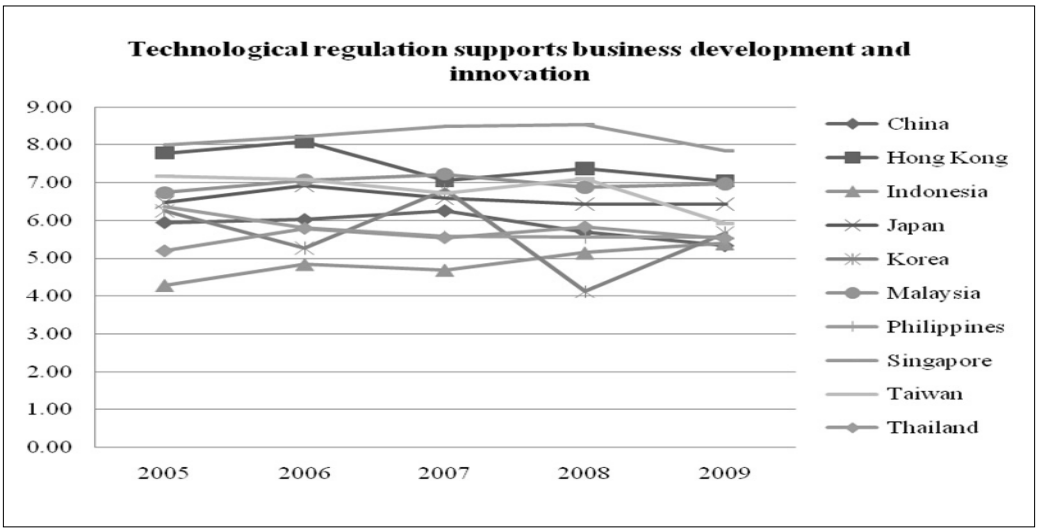

Figure 11. Technological Regulation, East Asia**

** IMD WCY Executive Opinion Survey based on an index from 0 to 10.

Source: Computed from data collected from IMD World Competitiveness Online 1995-2009. Updated: May 2009.

powerfully supporting the business development and innovation (See Figure 11).

The funding for technological development both by governments and private

initiatives significantly increased since 2000 in most of the advanced knowledge-based economies in East Asia (See Figure 12). This is playing a crucial role in the rapid development of ICT in the region.

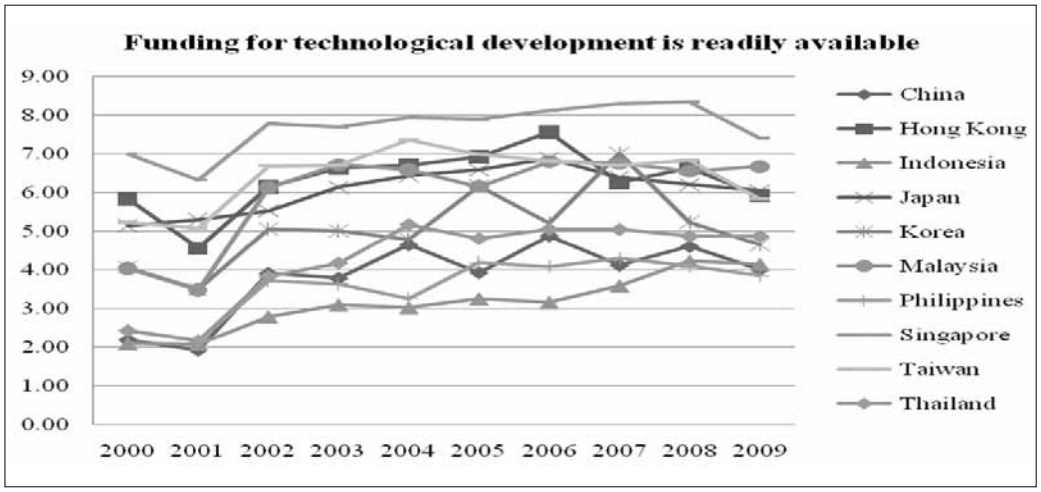

Figure 12. Funding for Technological Development, East Asia*

* IMD WCY Executive Opinion Survey based on an index from 0 to 10.

Source: Computed from data collected from IMD World Competitiveness Online 1995-2009. Updated: May 2009.

Ⅶ ICT as Industry

The advanced East Asian knowledge-based economies have experienced strong growth in ICT sector in many ways such as ICT production, trade and investment in the past few years. The ICT-producing sector itself is very highly globalized as ICT components and parts, telecommunication and computer equipments are manufactured in different locations and there is a significant shift in the production, from the high labor cost countries to low labor cost countries in East Asia (Information Economy Report 2007-2008; 101).

During the past decade, there has been clear growth in the production of electronics in East Asia. In fact, East Asia combined with Pacific nations (Australia and New Zealand) continues to be the fastest growing region for electronic production (See Table 3). Among the five major knowledge-based economies of East Asia, Japan alone experienced 7.6 percent growth during the 2002-2005 period. On the other hand, Asia's total share in electronics industry grew from 48 percent of world production in 2002 to 52 percent in 2005.

Table 3. Global production of electronics, 2002-2005 (US $ billions)

Region	2002	2003	2004	2005	Compound Annual Growth Rate 2002-2005
Europe	220.4	247.5	279.1	285.8	9.0%
Americas	317.6	314.1	334.3	341.9	2.5%
Asia-Pacific	343.1	386.9	448.8	492.7	12.8%
Japan	162.4	180.2	197.8	202.3	7.6%
Rest of the world	13.2	14.3	15.7	16.2	7.2%
World	1056.8	1143.0	1275.6	1338.9	8.2%

Source: Adapted from Reed Research, presented by Ernie Santiago, SEIPI, WTO ITA Symposium, 28 March 2007, Geneva.

ICT plays an important role in the division of regional and global value-added chain and in shifting parts of production to different geographical locations. By using ICT, the enterprises are able to exchange knowledge and information online from anywhere in the world, communicate just-in-time with clients and suppliers and deliver services efficiently and promptly (Information Economy Report 2007-2008, 101). ICT, in many cases, created opportunities for businesses to be more cost effective through outsourcing and offshoring. In the East Asian knowledge-based economies, the share of ICT sector value added in total business-sector value added continues to grow (UNCTAD Information Economy database, 2007). Among the five advanced knowledge-based economies, Japan performed best.

As a result of the increasing use of ICT, the ICT sector employment has experienced stable growth over the recent years in the region. Japan has the highest employment in electrical and electronic products manufacturing industry, which is a major part of ICT sector currently followed by Korea in the second place (Information Economy Report, 2007-2008: 110). Taiwan, Hong Kong and Singapore also experienced huge employment growth in this sector over the recent years.

Ⅷ Trade in ICT Goods and Services in East Asia

The past decades have witnessed stable growth in ICT-related trade in the East Asian economies as most of the economies are recipients of huge volume of FDI. Since 1996, the value of world exports of ICT goods has more than doubled, reaching US $ 1.5 trillion in 2005 (Information Economy Report 2007-2008, 115). Among the various regions of world, East Asia and Pacific is leading in terms of ICT goods exports (See Figure 13). East Asia dominates the world trade in ICT goods as the advanced knowledge-based

economies of East Asia along with developing China, Malaysia, Thailand and Philippines are among the top 10 exporters of ICT goods or have important export shares compared to other developed economies (Information Economy Report 2007-2008, 117).

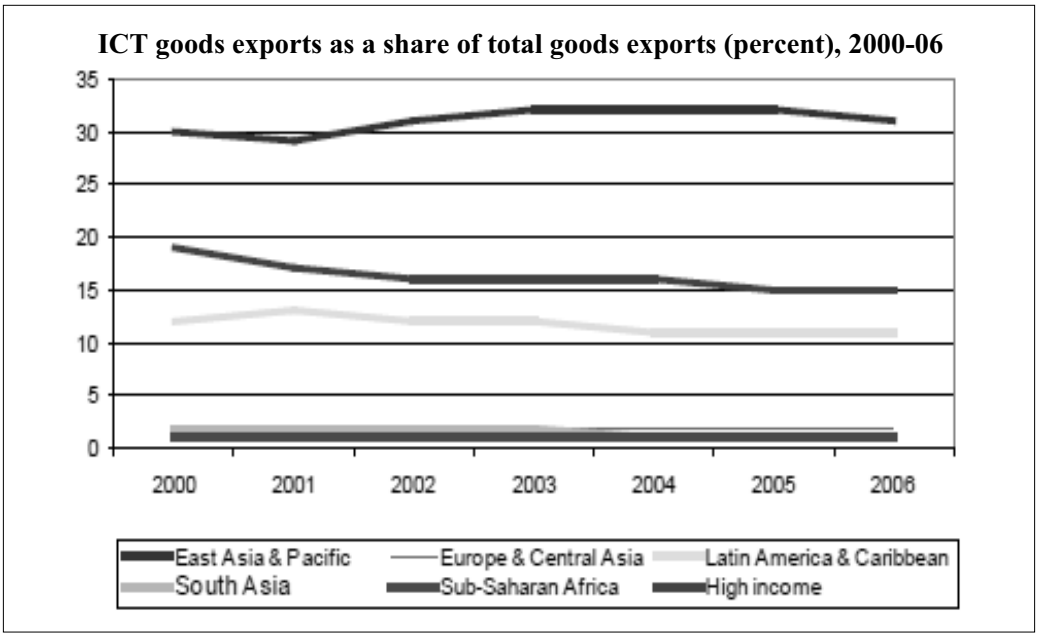

Figure 13. ICT goods exports as a share of total goods exports (percent), 2000-06
Source: World Development Indicators 2009.

Table 4. Exports of ICT goods, 1996, 2000 and 2005 (US $ millions)

Country	1996	2000	2005	Compound Annual Growth Rate 2000-2005	Compound Annual Growth Rate 1996-2005
China	18584	46996	235167	32.6%	38.0%
Hong Kong	37643	55313	118237	13.6%	16.4%
Indonesia	3287	7844	7911	10.2%	0.2%
Japan	103213	123548	121474	1.8%	-0.3%
Korea	34316	61525	87163	10.9%	7.2%
Malaysia	36987	55582	64472	6.4%	3.0%
Philippines	10294	26422	24418	10.1%	-1.6%
Singapore	67742	77345	106576	5.2%	6.6%
Taiwan	N/A	64409	66506	N/A	0.6%
Thailand	14208	20318	26169	7.0%	5.2%

Source: Adapted from Information Economy Report 2007-2008.

Over the years since 1996, most East Asian knowledge-based economies have experienced growth in the ICT goods exports except for Japan which has experienced a decline in 2005 (See Table 4). Other developing economies in East Asia also experienced growth in ICT good exports since 1996. This indicates the fact that the developed and developing countries in East Asia together are the leading exporters of ICT goods.

On the importing side, the advanced knowledge-based economies have significant shares of world imports as for ICT goods and services. The developing economies in East Asia such as China, Malaysia, Thailand and Philippines also experienced significant growth in ICT goods imports along with the advanced economies in East Asia (See Table 5).

Table 5. Imports of ICT goods, 1996, 2000 and 2005 (US $ millions)

Country	1996	2000	2005	Compound Annual Growth Rate 1996-2005	Compound Annual Growth Rate 2000-2005
China	16850	50597	183025	6.7%	3.8%
Hong Kong	44831	64403	119967	12.9%	11.2%
Indonesia	2851	1001	2426	5.9%	8.1%
Japan	47858	66871	76454	5.3%	2.3%
Korea	23482	39086	47037	8.6%	9.2%
Malaysia	27024	37249	46105	10.0%	4.8%
Philippines	9911	12621	23333	8.2%	8.7%
Singapore	50429	59769	80417	5.8%	1.1%
Taiwan	N/A	44851	45068	19.2%	10.5%
Thailand	13160	15660	23213	5.3%	6.1%

Source: Adapted from Information Economy Report 2007-2008.

On the other hand, the high-tech exports have been increasing for the last eight years (See Figure 14). In this case, it is notable that China has surpassed all the East Asian economies and is number one among ICT good exporters today. China's phenomenal success in this regard is largely due to the fact that the country is the highest recipient of FDI in East Asia. Even almost all of the East Asian advanced economies have shifted their production sites to China for cheap labor costs. Again, if we look at the percentage of high-tech exports of the total manufactured exports, we see that most of the advanced East Asian knowledge-based economies have maintained steadiness while in some countries the percentage has dropped since 2000 (See Figure 15), indicating that the exports of manufactured products is still increasing parallel with the high-tech exports in the East Asian economies.

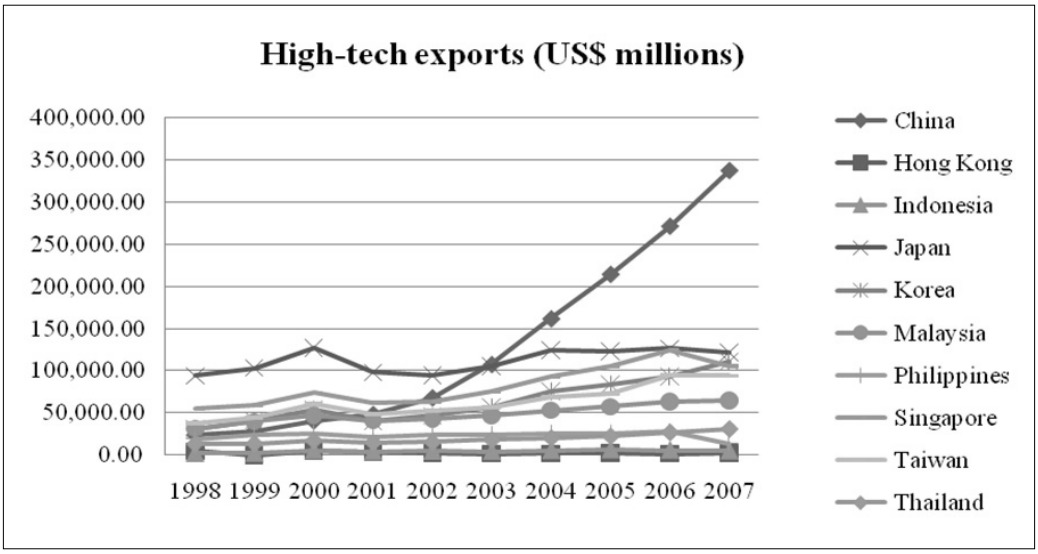

Figure 14. High-tech Exports as of total volume, East Asia

Source: World Development Indicators database March 2009, World Bank and National Sources.

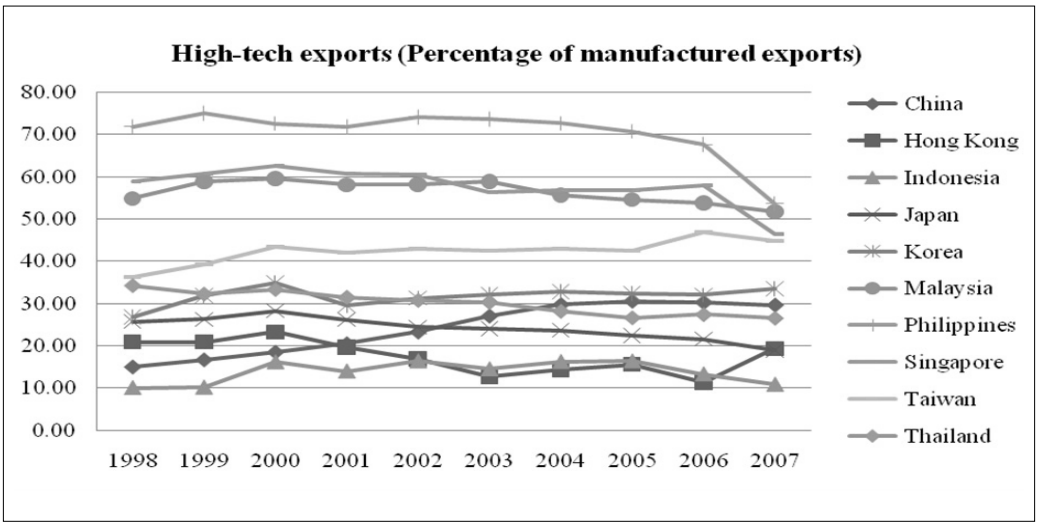

Figure 15. High-tech Exports as of manufactured exports, East Asia

Source: World Development Indicators database March 2009, World Bank and National Sources.

IX Macroeconomic Impact of ICT in East Asia

The impact of information and communication technologies is vast on the economic development of the East Asian countries. During the last two decades, ICT has evolved, improved and become more prevalent not only in advanced knowledge-based economies in East Asia but also in the developing economies in the region. The exports of ICT goods and services have been continuously growing in most of the economies in the region. Simultaneously, the ICT-related jobs grew over the years as both FDI and domestic investments flew into the ICT sector. In the advanced knowledge-based economies of East Asia, the economic gain derives both from ICT-producing sector and from other sectors that are using ICT for production efficiency and cost reduction. However, the developing East Asian countries while experiencing some growth in the ICT use in different sectors to bring efficiency still depend on the ICT-producing sector to derive economic benefits.

UNCTAD Information Economy Report 2007-2008 summarizes the way by which ICT use leads to productivity growth: *first,* it increases the efficiency of factor inputs (capital and labor) and *second*, it fosters technological innovation as a source of total factor productivity growth. Since the mid 1990s, the advanced East Asian countries such as Japan, Korea, Taiwan, Hong Kong and Singapore along with other countries in the region started to invest in ICT at faster rates and have acquired a considerable stock of ICT capital that matches the ICT capital intensity in the United States in the early 1990s (Information Economy Report 2007-2008, 155). Countries like Japan, Korea, Taiwan, Hong Kong and Singapore have specialized in the production of ICT goods to mainly meet the domestic demand and the ICT-producing sector has a sizeable positive effect on total factor productivity growth in the mentioned countries (Information Economy Report 2007-2008, 159).

X Identifying the Key Contributing Factors of ICT in East Asia

From the analysis, it is clear that the relationship between ICT and the creation of knowledge-based economy in East Asia is positively correlated. From the above discussion and data analysis of the East Asian countries, it is quite evident that advanced knowledge-based economies such as Japan, Korea, Taiwan, Hong Kong and Singapore are highly successful in the development of appropriate information and communications technology. There has been greater public and private ICT expenditure in the above mentioned countries over the years that led the boom of ICT development in the region to create a knowledge-based economy. Number of main lines and mobile telephone per 1000

people, computers per capita, number of internet users, and appropriate cyber security measures are major contributing factors of ICT developments in the East Asian countries. They have greatly helped in enhancing competitive business environment through providing better communications technology that meets the business requirements. Availability of high information technology skills, better technological cooperation between and among the companies and supporting public, private sector ventures for technological development, appropriate legal environment for the development and application of technology, suitable technological regulations to support the business development and innovation and availability of sound funding for technological development are also some of the very key contributing factors of ICT development in the East Asian countries that are enhancing the rapid growth of knowledge-based economy in the region. There has been very positive impact of these factors in the growth of global production of electronics making East Asia along with the Pacific the number one region in electronics production. Over the years from 2002 to 2005 East Asia experienced more than 12% annual growth in this sector. East Asia and Pacific also recorded highest volume of ICT goods exports for the 2000-2006 period. Again, the volume of high-tech exports also has been substantially increased over the years in the East Asian countries. So, it is quite evident that the key factors of ICT development identified in this study have significantly improved the ICT sector of the East Asian economies in their pursuit towards a knowledge-based economy.

Ⅺ Analysis of ICT in East Asia

From the discussions above, we found eleven factors that are contributing to the development of superior information communications technology in the East Asian economies. Main telephone lines per 1000 people, mobile telephones per 1000 people, computers per 1000 people, internet users per 1000 people, emphasize on cyber security, quality communications technology, availability of information technology skills, technological cooperation among the companies, technological regulations, public and private ventures for technological development, and legal environment for the development of technology and application are main factors that contribute to the development of information and communications technology of the East Asian economies.

As the first step, we have investigated the descriptive statistics to study the minimum, maximum, mean and standard deviation of all variables. Table 6 shows the descriptive statistics of all the variables for information and communications technology in East Asia that describes the characteristics of each variable by the measuring the total number of observance, minimum, maximum, mean and standard deviation of each

variable.

As for the second step, Table 7 shows the correlation of each independent variable with the dependent variable information and communications technology. From the correlation analysis, we can see that the dependent variable is not equally significantly associated with all the independent variables that are discussed in section X. The association of mainline telephone per 1000 people, computers per 1000 people and internet

Table 6

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
ICT	10	3.59	8.67	5.77	1.82
MainLinesper1000people	10	44.80	622.80	315.04	210.22
MobileTelephoneper1000people	10	353.30	1492.00	909.96	382.57
ComputersPer1000people	10	30.94	712.21	382.68	298.02
InternetUsersPer1000	10	117.22	774.31	485.08	290.85
Cyber Security	10	4.67	7.46	5.79	.87
Quality Communication Technology	10	6.19	8.83	7.72	.93
Information Technology Skills	10	5.95	8.59	7.38	.90
Technological Cooperation	10	4.21	7.41	5.84	1.15
Technological Regulations	10	5.34	7.85	6.17	.86
Public & Private Ventures	10	4.65	7.93	6.21	.91
Legal Environment for Development & Application of Technology	10	5.20	8.30	6.48	.98
Valid N (listwise)	10				

Table 7

Correlations												
		Main Lines per 1000 people	Mobile Telephone per 1000 people	Computers per 1000 people	Internet Users per 1000	Cyber Securit	Quality Communi-cation Technology	Information Technology Skills	Technolog-ical Cooperati-on	Technolog-ical Regulations	Public & Private Ventures	Legal Environment for Development & application of Technology
ICT	TPearson Correlation	.657*	.319	.709*	.665*	.252	.605	.482	.338	.027	.425	.246
	Sig. (2-tailed)	.039	.369	.022	.036	.483	.064	.159	.340	.941	.220	.494
	N	10	10	10	10	10	10	10	10	10	10	10
*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).												

users per 1000 people are significant at 0.05 level, while the association of information and communications technology in East Asia with the other variables is found not statistically so significant.

In the third step, we have investigated the curvilinear regression for each statistically

Table 8. Model Summary and Parameter Estimates for Curvilinear Regression

Dependent Variable: Information and Communications Technology							
Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
The independent variable is Mainline Telephones per 1000 people							
Linear	.432	6.091	1	8	.039	3.971	.006
Growth	.459	6.785	1	8	.031	1.397	.001
The independent variable is Computers per 1000 people							
Linear	.502	8.076	1	8	.022	4.108	.004
Growth	.531	9.071	1	8	.017	1.422	.001
The independent variable is Internet Users per 1000 people							
Linear	.443	6.352	1	8	.036	3.744	.004
Growth	.457	6.731	1	8	.032	1.363	.001

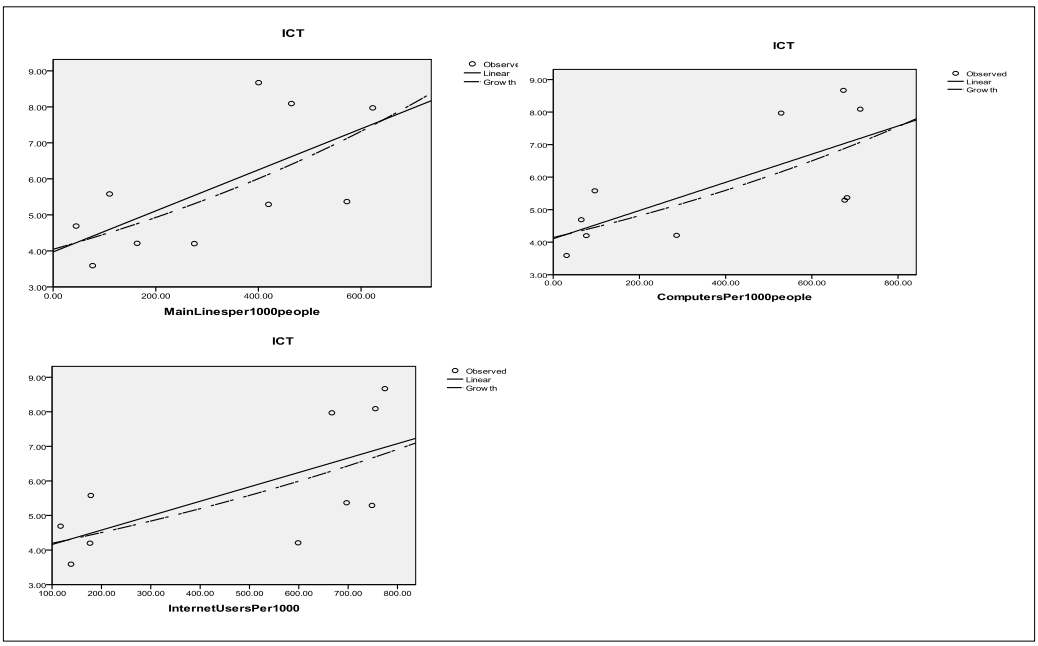

Figure 16. Curvilinear Regression Results

significant independent variable against the dependent variable 'information and communications technology' to explore the linear and growth relationship between them. Table 8 provides the model summary and parameter estimates for curvilinear regression while Figure 16 shows the curvilinear regression results in graphs. From Table 8, looking at the R square value and the significance level, we can understand that all the independent variables that have been identified in Table 7 as the determinants of ICT in the East Asian region, have close association with the dependent variable both in terms of linear and growth. In Figure 16, these findings are graphically represented.

XII Discussion on the Key Determinants of ICT in East Asia

In sections II-IX of this paper, we have observed that there has been greater public and private ICT expenditure in most of East Asian countries over the years that led the boom of ICT development in the region to create a knowledge-based economy. Factors such as number of main lines and mobile telephone per 1000 people, computers per capita, number of internet users, and appropriate cyber security measures have greatly helped in enhancing competitive business environment through providing better communications technology that meets the business requirements. Availability of high information technology skills, better technological cooperation between and among the companies and supporting public, private sector ventures for technological development, appropriate legal environment for the development and application of technology, suitable technological regulations to support the business development and innovation and availability of sound funding for technological development are some of the other factors of ICT development in the East Asian countries that are enhancing the rapid growth of ICT industry in the region. However, from the statistical analysis, we observed that the correlation between ICT and mainline telephone per 1000 people, computers per 1000 people and internet users per 1000 people are significant at 0.05 level, while correlation with the other factors are found statistically not so significant. Although, all the factors that are discussed in sections II-X contribute to the development of ICT in East Asia, however, availability of mainline telephone, computers and internet have been the key factors in this regard. So, from the discussions in sections II-IX and statistical analysis in section XI in this paper we can say that mainline telephone, computers and internet are the key determinants of ICT to promote knowledge-based economy in the region.

XIII A Comparative Look at World Bank Knowledge-based Economy Index for East Asia and Findings of this Study

From the empirical data analysis and discussions above, we see that Japan, Korea, Taiwan, Hong Kong and Singapore are most successful countries in East Asia to develop ICT infrastructure in their pursuit to become a knowledge-based economy. To further understand our findings in a more meaningful manner, we compared our findings with World Bank's knowledge economy indices. The Knowledge Economy Index (KEI) provided by the World Bank takes into account whether the environment is conducive for knowledge to be used effectively for economic development. The KEI score an aggregate index that represents the overall level of development of a country towards the Knowledge Economy. The index is calculated based on the average of the normalized performance scores of a country on all 4 pillars - economic incentive and institutional regime, education and human resources, the innovation system and information and communications technology (ICT). In making the KEI indices, World Bank considered 3 key variables for each pillar such as for economic incentives and institutional regimes tariff and nontariff barriers, regulatory quality and rule of law, for education and human resources, adult literacy rate, gross secondary enrollment and gross tertiary enrollment, for information and communications technology, number of total telephones per 100 people, computers per 1000 people and internet users per 1000 people and for innovations, the Bank

Table 9. A Comparative Look into World Bank Index and Findings of this study for the East Asian Countries

Country	KBE Index		Economic Incentives & Institutional Regimes		Education & Human Resources		ICT Index		Innovations Index	
	World Bank	Findings	World Bank	Findings	World Bank	Findings	World Bank	Findings	World Bank	Findings
China	4.47	4.71	3.90	3.90	5.44	3.91	4.20	5.17	4.33	5.84
Hong Kong	8.32	7.98	9.54	9.54	9.04	5.78	5.37	9.26	9.33	7.35
Indonesia	3.29	3.65	3.66	3.66	3.19	3.64	3.59	2.75	2.72	4.57
Japan	8.42	8.15	7.81	7.81	9.22	7.81	8.67	8.43	8.00	8.54
Korea	7.82	7.67	6.00	6.00	8.60	7.44	8.09	9.19	8.60	8.04
Malaysia	6.07	6.04	6.11	6.11	6.82	4.80	4.21	6.90	7.14	6.34
Philippines	4.12	3.93	4.37	4.37	3.80	4.70	4.69	3.22	3.60	3.44
Singapore	8.44	8.40	9.68	9.68	9.58	5.84	5.29	8.85	9.22	9.22
Taiwan	8.45	8.19	7.42	7.42	9.27	7.83	7.97	9.38	9.13	8.12
Thailand	5.52	5.08	5.12	5.12	5.76	5.55	5.58	4.62	5.64	5.03

considered royalty and license fees payments and receipts, patent applications granted by the US patent and trademark office and scientific and technical journal articles. The three key variables are found to be the most significant variables for each pillar of knowledge-based economy for all the countries of world. However, our study is about East Asian economies, and very reasonably we found that not all the variables prescribed by the World Bank are highly significant for the development of knowledge-based economy in East Asia.

For information and communications technology (ICT), we found that mainline telephone per 1000 people, computers per 1000 people and internet users per 1000 people are significant. Computers per 1000 people and internet users per 1000 people are also considered by World Bank. However, for the number of total telephones per 1000 people which is the third variable according to the World Bank's study, we found that number of mobile phones per 1000 people is not so significant for ICT in East Asia. Consequently, we replaced total telephones per 1000 people with mainline telephones per 1000 people to investigate the changes in the ICT indices for the East Asian economies. From Table 9, we see that the indices of the selected East Asian countries changed negatively. This difference between the World Bank's Index and our findings does not indicate any inferiority of World Bank's findings rather, it re-affirms the fact that there are common factors of knowledge-based economy for all the countries of the world while some factors are more relevant for some countries or regions because of geopolitical and historical settings and same is true for the East Asian economies. So, we can say that World Bank's knowledge economy index provides us with excellent indications of development of knowledge-based economy in different countries of the world. However, to explore more to understand the key determinants of a country's knowledge-based economy, we have to study more deeply and more concisely.

XV Tracking the Relationship between the Key Determinants of ICT and East Asia's Overall Development

The purpose of creating knowledge-based economy is to have a globally strong and competitive economy to maintain sustainable economic growth towards overall development of a country. The East Asian economies have been pursuing necessary policies to develop the ICT infrastructure in order to continue their knowledge-based economic development in the post-industrial era and to be globally competitive. In doing so, some economies in the region became exceptionally successful in creating a functional knowledge-based economy while some others are behind. Countries like Japan, Korea, Taiwan, Hong Kong and Singapore have shown remarkable achievements in creating a

successful knowledge-based economy. To understand the development trend in the East Asian ICT development, we did not investigate the GDP growth because the bigger the economy grows, the lower the GDP growth rate becomes although the absolute value of GDP is always higher in the advanced countries. For this reason, we considered the human development index (HDI), which is a composite measure of three components: longevity (measured by life expectancy) ; knowledge (adult literacy rate and mean years of schooling) ; and standard of living (real GDP per capita in purchasing power parity) to understand the development pattern in the East Asian knowledge-based economies. HDI provides information on the human development aspect of economic growth (World Bank, 2010).

Table 10 shows the HDI for the East Asian economies for the year 1980, 1985, 1990, 1995, 2000, 2005, 2006, and 2007. From the table, we observe that there has been a positive growth trend of human development in all the economies of East Asia while the advanced knowledge-based economies achieved incredible success in this regard which can be compared with the most advanced nations of the world. From this finding, it is obvious that most of the East Asian economies have achieved excellent growth in life expectancy, adult literacy rate and mean years of schooling, and real GDP per capita in purchasing power parity.

We, then, investigated the correlations between the key determinants of ICT identified in our findings with HDI. Table 11 shows the correlation of each determinant with the HDI for information and communications technology. Considering the

Table 10 Human Development Index Trends in East Asia

Country	1980	1985	1990	1995	2000	2005	2006	2007
China	0.533	0.556	0.608	0.657	0.719	0.756	0.763	0.772
Hong Kong	N/A	N/A	N/A	N/A	N/A	0.939	0.943	0.944
Indonesia	0.522	0.562	0.624	0.658	0.673	0.723	0.729	0.734
Japan	0.887	0.902	0.918	0.931	0.943	0.956	0.958	0.960
Korea	0.722	0.760	0.802	0.837	0.869	0.927	0.933	0.937
Malaysia	0.666	0.689	0.737	0.767	0.797	0.821	0.825	0.829
Philippines	0.652	0.651	0.697	0.713	0.726	0.744	0.747	0.751
Singapore	0.785	0.805	0.851	0.884	N/A	N/A	0.942	0.944
Taiwan	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.943
Thailand	0.658	0.684	0.706	0.727	0.753	0.777	0.780	0.783

Source: Human Development Report 2009 available at
http://hdrstats.undp.org/en/indicators/81.html and
http://www.dgbas.gov.tw/public/Data/910616273671.pdf for Taiwan's data

Table 11. Correlations

	Information and Communications Technology			
		Main Lines per 1000 people	Computers per 1000 people	Internet Users per 1000
Human Development Index	Pearson Correlation	.917**	.966**	.927**
	Sig. (2-tailed)	.000	.000	.000
	N	10	10	10
	**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).			

determinants of information and communications technology from our findings, we notice that all the determinants have highly significant correlations with HDI at 0.01 level (See Table 11). This clearly indicates the growing contribution of information and communications technology to the overall human development in the East Asian countries.

From the discussion in this section, we can clearly realize that the key determinants of ICT to promote knowledge-based economy in East Asia indeed causing human development in the region. This reaffirms the validity of our findings in this paper. Our argument about the findings of this study is that there are many factors that are contributing to the development of ICT in East Asia. However, there are some key factors that are contributing more than others in the development of ICT in the region. From the analysis, this argument is held true.

XV Concluding Remarks

Through qualitative discussions and empirical data analysis, the key factors of ICT became very evident for the selected East Asian countries. From the analysis in the above sections, we also found that there has been a very positive growth trend for most of the factors of ICT in the East Asian countries. This indicates the fact that, in fact, all the selected countries in East Asia have been putting tremendous efforts to develop ICT in their pursuit to promote knowledge-based economy.

In terms of ICT developments, main telephone lines per 1000 people, mobile telephones per 1000 people, computers per 1000 people, internet users per 1000 people, emphasize on cyber security, quality communications technology, availability of information technology skills, technological cooperation among the companies, technological regulations, public and private ventures for technological development, and legal environment for the development of technology and application are the main factors

identified that contribute to the development of information and communications technology in the region. However, from the statistical analysis that we discussed in section XI, it is evident that not all the factors that are mentioned and discussed in sections II-X are equally significant for creating better ICT infrastructure to promote knowledge-based economy. From the statistical analysis, we identified the key determinants of ICT in East Asia and they are main telephone lines, computers and internet.

Our objective in this paper was to investigate the key determinants of ICT in East Asia to promote knowledge-based economy in the region. From the analysis, it is clear that there are some key determinants of ICT in the successful East Asian knowledge-based economies. Overall, in all the selected East Asian countries, the ICT sector is playing very important role in promoting knowledge-based economy in the region.

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